Variables related to the progress of parturition and probability of stillbirth in swine

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Abstract

Sow and piglet variables related to probability of stillbirth and to viability score were analyzed in litters from 98 multiparous Yorkshire sows. Immediately after the birth of each piglet, viability was scored using Randall's method. Sow variables related to the probability of stillbirth were average birth weight of the litter (p = 0.0001), sow age (p = 0.001), sow condition score (p = 0.003), length of gestation (p = 0.005), and number of piglets in the litter (p = 0.01). Sow variables related to average viability score were average birth weight of the litter (p = 0.001), standard deviation in birth weight in the litter (p = 0.02), sow age (p = 0.03), sow condition score (p = 0.03), and length of gestation (p = 0.03). Piglet variables related to probability of stillbirth were piglet hemoglobin (p = 0.0001), position in the birth order (p = 0.0001), broken umbilical cord (p = 0.0004), and preceding birth interval (p = 0.0004). Piglet variables related to viability score were piglet hemoglobin (p = 0.0001), position in the birth order (p = 0.0001), broken umbilical cord (p = 0.0001), preceding birth interval (p = 0.0001), and birth weight (p = 0.004). Preceding birth interval was related to whether the piglet was live or stillborn (p = 0.0001), to position in the birth order (p = 0.003), and to the sex of the piglet (p = 0.03).

The results demonstrated that sow and piglet variables were highly correlated to probability of stillbirth and to viability score. In addition it was also found that the probability of stillbirth was not associated with the duration of farrowing but with the number of piglets in the litter and piglet hemoglobin level. This study also found that lower weight piglets tend to have poor viability, but are not more prone to stillbirth as commonly suggested. These low viability piglets may survive if the necessary care is given during the farrowing process.

Résumé

Facteurs reliés au déroulement de la parturition et à la probabilité d'avoir des porcelets mort-nés

Les facteurs reliés aux truies et aux porcelets ayant un rapport avec la probabilité d'avoir des porcelets mort-nés et avec le taux de survie ont été analysés à partir des données provenant des mises bas de 98 truies multipares, de race Yorkshire. Dès la naissance des porcelets, un score de viabilité a été effectué par la méthode de Randall. Les facteurs reliés aux truies ayant un rapport avec la probabilité d'avoir des porcelets mort-nés étaient le poids moyen de la portée (p = 0,0001), l'âge de la truie (p = 0,001), le score de l'état général de la truie (p = 0,003), la durée de la gestation (p = 0,005) et le nombre de porcelets par portée (p = 0,01). Le facteurs reliés aux truies ayant un rapport avec le score moyen de viabilité étaient le poids moyen de la portée (p = 0,001), l'écart-type du poids moyen de la portée (p = 0,02), l'âge de la truie (p = 0,03), le score de l'état général de la truie (p = 0,03) et la durée de la gestation (p = 0,03). Les facteurs concernant les porcelets ayant un rapport avec la probabilité de porcelets mort-nés étaient le taux d'hémoglobine du porcelet (p = 0,0001), la position dans l'ordre de la naissance (p = 0,0001), la rupture du cordon ombilical (p = 0,0004) et l'intervalle entre les naissances (p = 0,0004). Les facteurs concernant les porcelets reliés au score de viabilité étaient le taux d'hémoglobine du porcelet (p = 0,0001), la position dans l'ordre de la naissance (p = 0,0001), la rupture du cordon ombilical (p = 0,0001), l'intervalle entre les naissances (p = 0,0001) et le poids à la naissance (p = 0,004). L'intervalle entre les naissances était relié au fait que le porcelet naissait vivant ou mort (p = 0,0001), à la position dans l'ordre des naissances (p = 0,003) et au sexe du porcelet (p = 0,03). Les résultats ont démontré que les facteurs reliés aux truies et aux porcelets avaient une forte corrélation avec la probabilité de naissances d'animaux mort-nées et avec le score de viabilité. De plus, la probabilité de porcelets mort-nés n'était pas associée avec la durée de la parturition, mais bien avec le nombre de porcelets par portée et leur taux d'hémoglobine. Cette étude a aussi démontré que les porcelets présentant un poids plus faible étaient plus susceptibles à une viabilité faible, mais n'étaient pas plus à risque à naître mort-né. Ces porcelets ayant une viabilité faible peuvent survivre si les soins nécessaires leur sont fournis lors de la parturition. *(Traduit par Dr Thérèse Lanthier)*

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Introduction

Previous work has shown that many variables are related to the increased occurrence of stillbirths.

Increased stillbirth rate in a litter is related to increasing litter size over nine piglets (1–3), previous litter size of more than 12 piglets (4), increasing parity of the sow (1,4,5), a history of stillbirths or low viability piglets in previous litters (4), increasing duration of farrowing (1), overweight sows (1,5), and sow blood hemoglobin of less than 9 g/100 mL (1).

An increased probability of a piglet being stillborn is related to later position in the birth order (1,6), low birth weight (2,3,7,8), a broken or damaged umbilical cord (8,9), and a longer interval preceding birth (1).

These variables, however, are not always independent. A higher number of piglets in a litter is related to longer duration of farrowing (8), shorter birth inter-

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Table 1. Viability score (adapted from Randall, 1971)

Item	Score 0	1	2
Heart rate	Absent	<120/min	>120/min
Onset of respiration	Absent	After 15 s	Before 15 s
Muscle tone	Flaccid	Poor	Good
Color	Pale	Cyanotic	Pink
Attempts to stand	None in 5 min	1 to 5 min	Before 1 min

vals (10), lower birth weights (7,8), and increasing parity (3). Birth intervals (6) and the proportion of piglets born with a ruptured umbilical cord (11) increase with position in the birth order. Older sows (3) and fatter sows (8) take longer to farrow.

The relative importance of the variables related to probability of stillbirth can only be established by considering them simultaneously.This study considered sow variables related to the average litter viability score and the probability of stillbirth in a litter, and piglet variables related to the individual viability score and the probability of a piglet being stillborn.

Materials and method

One hundred and nineteen multiparous Yorkshire sows farrowed naturally in climate controlled rooms at the Arkell Swine Research Station. Most sows were third litter or older. Of the 119 farrowings, ten were not attended, five sows gave birth to fewer than six piglets each, two sows gave birth to more than five deformed piglets each, one sow had scar tissue obstructing the uterus, and three sows took over 24 hours to deliver. The remaining 98 sows were used in a study of the effect of oxygen and neostigmine on the probability of stillbirth and on viability score (unpublished observations). Because treatment effects were not significant, the sow and litter data from these 98 farrowings were used to study sow and piglet variables related to probability of stillbirth and to viability score.

The sows were moved into farrowing crates on day 109 of gestation. A blood sample was obtained from the orbital venous sinus of each sow (12). Sow condition score was recorded on a scale of one to five, with one representing a very thin sow, three a normal sow, and five a very obese sow. Length of gestation was calculated as the time from the first day of mating to the day of parturition. Sow age was the time from the recorded birth date until the day of parturition. Sow age rather than parity was used because of the difficulty in accessing complete parity records for all sows.

As each piglet was born, the time of birth was recorded, the umbilical cord was checked, and the heart rate was measured for 10 seconds by placing a finger over the heart on the left side of the piglet. If a piglet was born inside the membranes, the membranes were immediately opened so that the measurements could be taken. When 15 seconds had elapsed from birth, the piglet was checked for onset of respiration, color, and muscle tone, and its sex was noted. Weak piglets were assisted in establishing respiration. From 30 seconds until one minute after birth, the piglet was monitored for attempts to stand. At one minute after birth, the piglet's head was dried, and a blood sample was obtained from the orbital venous sinus (12). The piglet was monitored until five minutes after birth or until it attempted to stand, whichever came first. All the above procedures were carried out without breaking the umbilical cord, if it was intact. The piglet was then weighed and placed at the udder. Any unusual circumstances at birth were recorded. As time permitted, weaker piglets were assisted to suckle.

Blood samples collected from both the sows and the piglets were utilized to analyze blood gases on a Radiometer ABL3 usually within 2 h of sampling. Hemoglobin, pO_2, pCO_2, and pH values were based on a body temperature of 39°C.

When 60 minutes passed with no births, any piglets within reach were manually extracted from the sow. Each piglet manually extracted was recorded as one intervention.

Viability score was assigned according to the method described by Randall (13) (Table 1). A stillborn piglet was defined as one that made no attempts at respiration, and a low viability piglet as one with a score of six or less.

Four models were used:

1. Sow variables vs. log probability of stillbirth in the litter,
2. Sow variables vs. average viability score of the litter,
3. Piglet variables vs. log probability of a piglet being stillborn, and
4. Piglet variables vs. individual viability score.

The relationships of sow and piglet variables to probability of stillbirth (models 1 and 3) were determined by logistic regression using Proc CATMOD (SAS Program, SAS Institute Inc., Cary, North Carolina, USA) (14). Because 54% of sows had no stillbirths, the data were not normally distributed, and a linear model could not be used (15). The log probability of stillbirth was given by:

$$\log\left(\frac{\text{stillbirth}}{\text{1-stillbirth}}\right)$$

where "stillbirth" is the proportion of piglets stillborn. The relationship of sow and piglet variables to piglet viability (models 2 and 4) was determined using the general linear models procedure Proc GLM (SAS Program, SAS Institute Inc.) (14). Sow variables included in the full models for probability of stillbirth and average viability score of the litter were total number of piglets in the litter, average birth weight of the litter, variability in birth weight within the litter as given by the standard deviation, duration of farrow-

Table 2. Sow variables related to log odds of stillbirth

Variable	Coefficient	Standard error	p
Intercept	25.4	10.4	0.01
Average birth weight of the litter (kg)	−3.29	0.74	0.0001
Sow age (years)	0.42	0.13	0.001
Condition score	0.92	0.31	0.003
Gestation length (days)	−0.256	0.091	0.005
Number in litter	0.123	0.049	0.01
SD of birth weight	Removed from model		0.1
Sow hemoglobin (g/100 mL)	Removed from model		0.2
Duration of farrowing (min)	Removed from model		0.6

Table 3. Sow variables related to decreased average viability score

Variable	Linear coefficient	Standard error	p
Overall mean	8.785	0.094	0.0001
Average birth weight of the litter (kg)	−1.89	0.56	0.001
SD of birth weight (kg)	3.4	1.5	0.02
Sow age (years)	0.23	0.11	0.03
Condition score	0.47	0.21	0.03
Gestation length (days)	−0.151	0.068	0.03
Number in litter	0.070	0.041	0.09
Sow hemoglobin (g/100 mL)	Removed from model		0.3
Duration of farrowing (min)	Removed from model		0.9

Table 4. Piglet variables related to the log odds of a piglet being stillborn

Variable	Coefficient	Standard error	p
Intercept	3.5	5.3	0.5
Piglet hemoglobin (g/100 mL)	−0.80	0.12	0.0001
Birth order	0.300	0.056	0.0001
Umbilical cord broken	0.79	0.22	0.0004
Intervention — first	−0.59	1.0	0.6
Intervention — subsequent	1.6	1.9	0.4
Preceding interval (min)			
Unassisted births	0.041	0.012	0.0004
First assisted birth	0.0078	0.044	0.9
Subsequent assisted birth	0.65	0.58	0.3
Sex male	Removed from model		0.7
Birth weight (kg)	Removed from model		0.9

ing, sow age, length of gestation, sow condition score, and prefarrowing sow hemoglobin. In all models, the significance of each variable was determined by comparing the model including all variables against the model including all variables except the one being tested. Any variables that were not significant at $p = 0.1$ were removed from the final models. Piglet variables related to log odds of stillbirth and piglet viability (models 2 and 4) were analyzed by including the sow in the model to remove sow effects. Birth intervals were analyzed using Proc Lifereg (SAS Program, SAS Institute Inc.) (14), with intervals ended by manual intervention treated as right censored intervals, so that the end of the interval was fitted between the time of intervention and the time of birth of the next piglet.

Results

The 98 farrowings averaged 12.2 piglets per litter. Of the 1200 piglets born, 1093 (91.1%) were live born, 93 (7.8%) were stillborn, and 14 (1.2%) were mummified. Of the live born piglets, 42 (3.8%) were of low viability, and 1051 (96.2%) were normal.

Sow variables related to increased log probability of stillbirth in a litter were lower average birth weight of the litter, increasing sow age, higher sow condition score, shorter length of gestation, and larger litter size (Table 2). Average litter viability score decreased with lower average birth weight of the litter, more variability in birth weight, increasing sow age, higher sow condition score, and shorter length of gestation (Table 3). The multiple correlation coefficient, R^2, for the model was 0.32.

Piglet variables related to the log probability of stillbirth of individual piglets are shown in Table 4. Probability of stillbirth increased with lower piglet hemoglobin, later position in the birth order, broken umbilical cord, and longer preceding birth interval in unassisted births. Piglet variables related to individual piglet viability score are shown in Table 5. Viability

Table 5. Piglet variables related to decreased viability score

a. Effect of quantitative variables

Variable	Linear coefficient	Standard error	p
Overall mean	8.588	0.071	0.0001
Sow			0.0001
Piglet hemoglobin (g/100 mL)	−0.566	0.056	0.0001
Birth order	0.154	0.020	0.0001
Birth weight (kg)	−0.84	0.29	0.004
Preceding interval (min)			
Unassisted birth	0.0162	0.0038	0.0001
First assisted birth	−0.0042	0.017	0.8
Subsequent assisted birth	0.038	0.088	0.7

b. Least squares means of qualitative variables

Variable	Viability score	Standard error	p
Umbilical cord			0.0001
Broken	7.63	0.56	
Intact	8.25	0.56	
Intervention			0.3
None	8.604	0.079	
First of group	7.06	0.88	0.08[a]
Subsequent in group	8.15	1.41	0.8[a]
Sex	Removed from model		0.6

[a]p value for contrast of assisted birth with unassisted birth

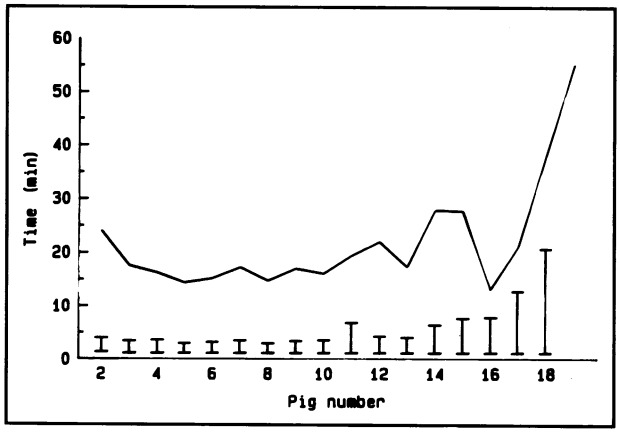

Figure 1. Variation of birth interval with pig number. Bars represent SEM.

score decreased with lower piglet hemoglobin, later position in the birth order, broken umbilical cord, longer preceding birth interval in unassisted births, and lower birth weight. The R^2 for the model was 0.41.

The relationship between birth interval and position in the birth order was linear, with a regression coefficient of 0.564 ($p = 0.003$) (Figure 1). Birth intervals were longer for stillborn than for live piglets (28.1 min vs. 15.3 min; $p = 0.0001$), and longer for female than for male piglets (23.2 min vs. 20.2 min; $p = 0.03$), but were not related to piglet weight, piglet hemoglobin, or to condition of the umbilical cord.

Discussion

The relationships of sow and piglet variables to viability scores and to probability of stillbirth were generally very consistent with each other. Individual viability scores are highly correlated with venous pCO_2 and pH of piglets (unpublished observations). These two observations indicate that viability score is an excellent indicator of the severity of asphyxia suffered by piglets during parturition. Viability scoring is a fast, easy-to learn method of viability assessment that is readily used under field conditions.

The sow variables related to the probability of stillbirth in a litter were average birth weight of the litter, sow age, sow condition score, length of gestation, and number of piglets in the litter. When these variables were included in the model, duration of farrowing, sow hemoglobin, and variability in piglet weight were not significant. The sow variables were not all independent, average birth weight of the litter decreased as number of piglets in the litter increased, and increased as sow condition score and sow hemoglobin increased. Sow condition score increased as sow hemoglobin increased. As the number of piglets in the litter increased, average birth weight of the litter and sow hemoglobin decreased, and duration of farrowing and variability or standard deviation of birth weight increased. Only sow age and length of gestation had low correlations (less than 0.15 in absolute value) with the other sow variables.

The results of this study differ from previous reports of an increase in stillbirths with a longer duration of farrowing (1,9,16). The difference probably arises because larger litters have a longer duration of farrowing; when both number of piglets in the litter and duration of farrowing were included in the model, the number of piglets in the litter rather than the duration of farrowing was related to probability of stillbirth.

Farrowings lasting over 24 hours (one sow delivered 10 piglets in three hours and one stillborn piglet three days later, one sow delivered eight piglets in three hours and three stillborn piglets one day later, one sow that was sick during the week prior to farrowing delivered her litter over several days, and one sow delivered seven deformed piglets over more than 24 hours) were excluded from this study, because they were not considered to be normal farrowings.

Probability of stillbirth has been reported to increase rapidly with gestation of less than 110 days, when sows are induced to farrow. All the sows in this study farrowed naturally, and the shortest gestation was 111 days. The increase in probability of stillbirth with shorter gestation may be related to differences in piglet maturity.

The sow variables related to average viability score were the same as those related to probability of stillbirth, with the exception of variability in birth weight, which was related to viability score but not to probability of stillbirth, and number of pigs in the litter, which was related to probability of stillbirth but not to the average viability score. The similarity in the relationships of sow variables to probability of stillbirth and to average viability score is consistent with the causation of stillbirth and reduced viability by differing severity of asphyxia during parturition.

The variables related to the probability of stillbirth of a piglet within a litter were piglet hemoglobin, position in the birth order, condition of the umbilical cord, and the length of the interval between births. The relationship of piglet hemoglobin to probability of stillbirth has not previously been reported, although stillbirth rate has been reported to increase when sow hemoglobin is less than 9 g/100 mL (1,17). The piglet variables were not all independent, piglet hemoglobin was positively correlated with birth weight and with an intact umbilical cord, and negatively correlated with position in the birth order. Position in the birth order was positively correlated with probability of intervention. All other correlations were less than 0.15 in absolute value.

Variables that were not significantly related to the probability of a piglet being stillborn were intervention, other than its interaction with the preceding birth interval, birth weight, and sex. The lack of relationship between birth weight and stillbirth contrasts with previous reports (2,3,7,8). In this study, the average birth weight of the litter, rather than individual piglet birth weight, was related to probability of stillbirth. It is possible that the average birth weight of the litter reflects the quality of uterine support of the litter, and therefore the vigor of the litter at the onset of parturition. The effect of a broken umbilical cord was additional to the effect of position in birth order, suggesting that the effect of a later position in the birth order cannot be explained only by the increased danger of breaking the cord as distance travelled through the uterus increases.

The variables related to the piglet viability score were the same as those related to the probability of stillbirth, with the exception of birth weight, which was related to viability score but not to probability of stillbirth. These results suggest that, while piglet birth weight is not related to the severity of asphyxia suffered during parturition, birth weight is related to the ability of the piglet to adapt to the extrauterine environment in the immediate postnatal period. Low birth weight reduces the chances of survival to weaning of the piglet (18).

The importance of birth weight in probability of stillbirth and in viability suggests that more attention might usefully be paid to the quality of uterine support of the litter, particularly during late gestation, through practices such as increasing the daily allotment of feed during the last weeks of gestation.

The pattern of birth intervals observed is consistent with previous reports (6,10,11), with an increase in birth interval towards the end of farrowing. Duration of farrowing was not related to the probability of stillbirth or to litter viability. Preceding birth interval was related to the probability of stillbirth and to piglet viability, and birth interval is a variable that can be manipulated by manual intervention to remove the piglet when the interval exceeds a predetermined limit.

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References

1. Cutler R, Hurtgen JP, Leman AD. Reproductive system. In: Leman AD, Glock RD, Mengeling WL, Penny RHC, Scholl E, Straw B, eds. Diseases of Swine. 5th ed. Ames, Iowa: Iowa State University Press, 1981: 96–129.
2. Dyck GW, Swierstra EE. Causes of piglet death from birth to weaning. Can J Anim Sci 1987; 67: 543–547.
3. Szenci O, Bakonyi S, Benko J, Takacs E. Monitoring the course of farrowing by determination of the acid-base equilibrium of newborn piglets. Magy Allatorv Lap 1988; 43: 203–206. (Translated by E. Nagy.)
4. Blackwell TE. Predicting stillbirth problems. Compend Contin Educ Pract Vet 1987; 9: F371–F374.
5. Pejsak Z. Some pharmacological methods to reduce intrapartum death of piglets. Pig News Info 1984; 5: 35–37.
6. Edwards SA, Furniss SJ. The effects of straw in crated farrowing systems on peripartal behaviour of sows and piglets. Br Vet J 1988; 144: 139–146.
7. England DC. Husbandry components in prenatal and perinatal development in swine. J Anim Sci 1974; 38: 1045–1049.
8. De Roth L, Downie HG. Evaluation of viability of neonatal swine. Can Vet J 1976; 17: 275–279.
9. Randall GCB. Observations on parturition in the sow. II. Factors influencing stillbirth and perinatal mortality. Vet Rec 1972; 90: 183–186.
10. Stanton HC, Brown LJ, Mueller RL. Interrelationships between maternal and neonatal factors and thermoregulation in fasted neonatal swine (Sus domesticus). Comp Biochem Physiol (A) 1973; 44: 97–105.
11. Randall GCB. Observations on parturition in the sow. I. Factors associated with the delivery of the piglets and their subsequent behaviour. Vet Rec 1972; 90: 178–182.
12. Straw BE, Wilson MR. Diagnosis of Swine Diseases. South St Paul, Minnesota: Pig World, Inc., 1985: 10.
13. Randall GCB. The relationship of arterial blood pH and pCO_2 to the viability of the newborn piglet. Can J Comp Med 1971; 35: 141–146.
14. SAS Institute Inc. SAS/STAT User's Guide, Version 6. 4th ed. Volume 1 and 2. Cary, North Carolina: SAS Institute Inc., 1989.
15. Snedchor GW, Cochran WG. Statistical Methods. 8th ed. Ames, Iowa: Iowa State University Press, 1989: 420–430.
16. Friend DW, Cunningham HM, Nicholson JWG. The duration of farrowing in relation to the reproductive performance of Yorkshire sows. Can J Comp Med 1962; 26: 127–130.
17. Moore RW, Redmond HE, Livingston CW Jr. Iron deficiency anemia as a cause of stillbirths in swine. J Am Vet Med Assoc 1965; 147: 746–748.
18. English PR, Wilkinson V. Management of the sow and litter in late pregnancy and lactation in relation to piglet survival and growth. In: Cole DJA, Foxcroft GR, eds. Control of Pig Reproduction. London: Butterworth Scientific, 1982: 479–506.